

PATHPROX – A RUNWAY INCURSION ALERTING SYSTEM

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Abstract

This paper describes a Runway Incursion Advisory and Alerting System (RIAAS), intended to help minimize the number of runway incursions and provide conflict alerts for all aircraft and vehicles on the airport surface. Rannoch Corporation is the developer of PathProx, a RIAAS avionics system designed to provide timely alerts directly to the pilot. Airport surface incursions have been identified as one of the most significant safety hazards in civil aviation [1], and yet thus far, there is no operational system to alert pilots automatically at the onset of such conflicts. The FAA is currently testing ASDE-3/AMASS (Airport Movement Area Safety System) to detect airport surface incursions on the ground and to relay the information to aircraft pilots. However, the implementation of this system has been relatively slow and is still in its initial stages of testing.

PathProx is designed to monitor aircraft that are either on the airport surface area, or are still within the airport's arrival and departure zones. The prototype design specifies that the system is activated whenever an aircraft enters an arrival or departure zone associated with a runway. ADS-B and/or TIS traffic data from other aircraft and ground vehicles within the proximity of this zone are processed by the system, which tracks their movement. Decision rules are set up to issue alerts based on the states and proximity of the aircraft.

The goal of the system when implemented is a reduction in the number of runway incursions and also an improvement in the reaction time by pilots to avoid such conflicts.

Introduction

Rannoch Corporation is in the process of developing PathProx to provide runway incursion alerting to pilots in the airport surface environment. The development is being funded partially by NASA (National Aeronautics and Space Administration) through a cooperative agreement.

Runway Incursion Definition

A runway incursion is defined by the FAA [2] to be "any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground, that creates a collision hazard or results in the loss of separation with an aircraft taking off, intending to take off, landing, or intending to land." Runway Incursions are classified into four categories:

1. Pilot Deviations (PD) - An action of a pilot that results in violation of a Federal Aviation Regulation.
2. Operational Errors (OE) - An occurrence attributable to an element of the ATC system which results in:
 - less than the applicable separation minima between two or more aircraft, or between an aircraft and terrain or obstacles, as required by FAA Order 7110.65, Air Traffic Control, and supplemental instructions. Obstacles include vehicles/equipment/personnel on runways; or
 - an aircraft landing or departing on a runway closed to aircraft operations after receiving air traffic authorization.
3. Operational Deviations (OD) - Controlled occurrences where applicable separation minima, as referenced in the definition of operational error (see above) are maintained, but
 - less than the applicable separation minima existed between an aircraft and protected airspace without prior approval, or

- an aircraft penetrated airspace that was delegated to another position of operation or another facility without prior coordination and approval.
4. Vehicle/Pedestrian Deviations (VPD) - Incursions resulting from a vehicle operator, non-pilot operator of an aircraft, or a pedestrian who deviates onto the movement area (including the runway) without ATC authorization.

Runway Incursion Accidents

Following are descriptions of three accidents that resulted from runway incursions.

Los Angeles International: On February 1, 1991 a Sky West commuter aircraft was cleared by air traffic control into position and hold for takeoff on runway 24L. Subsequently the local controller forgot about the commuter aircraft's position and cleared a US Air 737 for landing on 24L. The 737 crashed into the commuter aircraft, resulting in the loss of both aircraft and 34 fatalities. [3]

Detroit Metropolitan: On December 3, 1990 a Northwest 727 was on its takeoff roll on runway 9 when it was struck by a Northwest DC-9, which had just taxied onto the active runway. The accident occurred in low visibility conditions due to dense fog. The DC-9 pilot was confused about his location and incorrectly taxied onto runway 9, causing a runway incursion and subsequently the accident. There were 8 fatalities and the DC-9 was destroyed. [4]

St. Louis Lambert: On November 22, 1994 a TWA MD-82 was on takeoff roll on runway 30R when it collided with a Cessna 441, in holding position for takeoff. The Cessna pilot had created a runway incursion by incorrectly believing that he was assigned 30R for takeoff, instead of runway 31, for which ATC had given clearance. The resulting accident included 2 fatalities. [5]

History of Runway Incursions and Prevention Measures

In 1991, following the Detroit accident and a record of 281 runway incursions in 1990 (Figure 1) [6], the FAA developed its first Runway Incursion Plan to study and resolve the cause of runway incursions. After some initial success in reducing the number of incursions in the early nineties, there has since been a steady increase. The FAA revised the plan in 1995 [7] and again in 1998 [8] (now known as the Runway Incursion Prevention Program – RIRP) to prevent runway incidents and accidents. Each plan addressed a combination of measures intended to reduce runway incursions. These included better training for the pilots and controllers, improved runway/taxiway signs and markings, and improved technology for monitoring aircraft and vehicle movements on the airport surface.

PathProx Goals

With proper conflict detection and alerting available to the controllers and/or pilots, the accidents described above could have been prevented. The FAA is deploying the Airport Movement Area Safety System (AMASS) as an add-on to the Airport Surface Detection Equipment 3 (ASDE-3) surface movement radar. ASDE-3/AMASS provides surface traffic display and runway incursion alerts to the ATC tower controllers. When an alert occurs and is reported to the tower, the controller must notify the flight crews involved in the incursion, so that they may take action to avoid a collision. However, the controller reaction time and voice communications delays cost valuable seconds in alerting the flight crew. Providing the alerts directly to the cockpit has the advantage of minimizing the delays in reporting alerts. This was recognized by the NTSB in a recommendation concerning the prevention of runway incursion related accidents [1]. NASA has developed a system for transmitting alerts generated by the AMASS ground system to the aircraft, and displaying them in the cockpit. This was done under the Low Visibility Landing and Surface Operations (LVLASO) program [9].

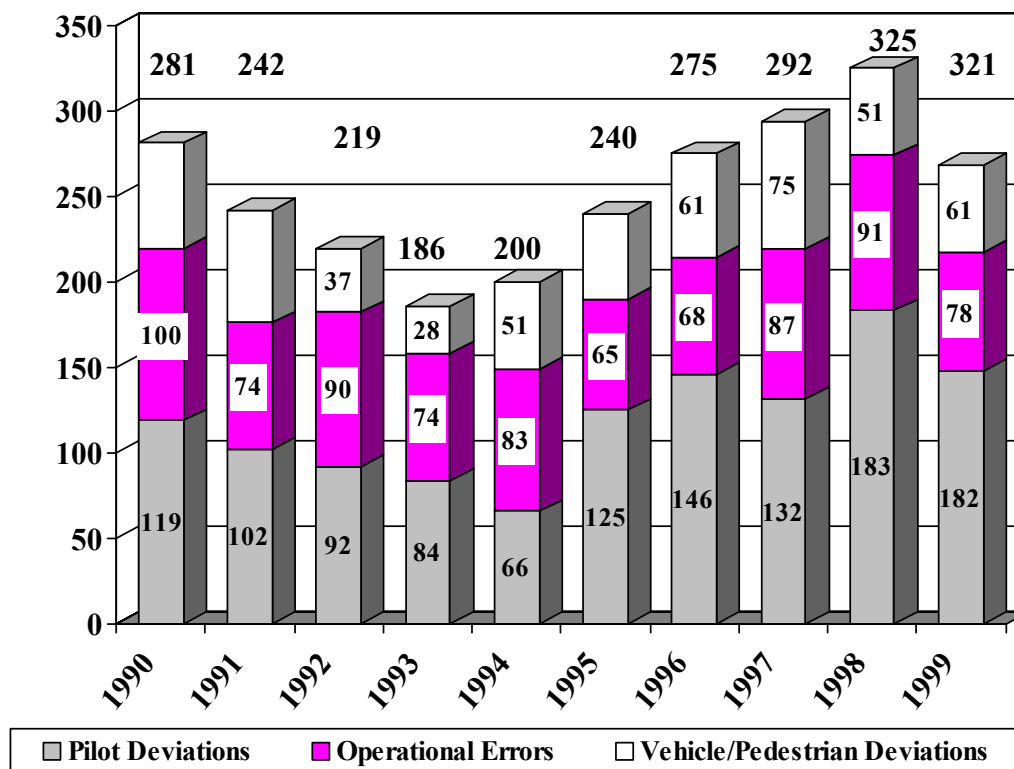


Figure 1. U.S. Runway Incursions By Type From 1990 To 1999

However, this technology would only be useable at airports equipped with ASDE-3/AMASS, which is a limited number of airports – 36. An avionics based collision avoidance capability is needed to ensure timely alerts and widespread applicability at most airports. That role can be filled by PathProx.

The goals established for the implementation of PathProx are:

- Increase the safety of aircraft and vehicle movement on the airport surface.
- Provide timely conflict alerting.
- Sharing of alerting information with ATC, pilots, vehicle operators, etc.
- Minimization of false alerts.

PathProx Conceptual Overview

PathProx is an on-board surveillance system designed to identify early conditions for runway incursions and provide aircraft pilots and ground vehicle operators with sufficient time to avoid runway incursions and collisions. Conceptually, the implementation of runway incursion and collision avoidance is similar to that of TCAS (Traffic Alert and Collision

Avoidance System). This will include system elements to acquire traffic information, algorithms to predict and detect runway incursions, and an alerting mechanism. The avionics and ground elements required to support the implementation of PathProx are shown in Figures 2 and 3.

Key PathProx Components

PathProx requires traffic information to be supplied by either TIS-B (Traffic Information Service – Broadcast) or ADS-B receivers. The alerting logic is the core of the PathProx algorithms. PathProx also needs a method for annunciating the alerts. It is planned that this be provided by CDTI (Cockpit Display of Traffic Information).

The implementation of PathProx also requires an infrastructure outside of the aircraft. Optimum implementation would include a ground system that includes a combination of airport surface surveillance sensors. Aircraft and vehicle position information is then broadcast to the aircraft via TIS-B.

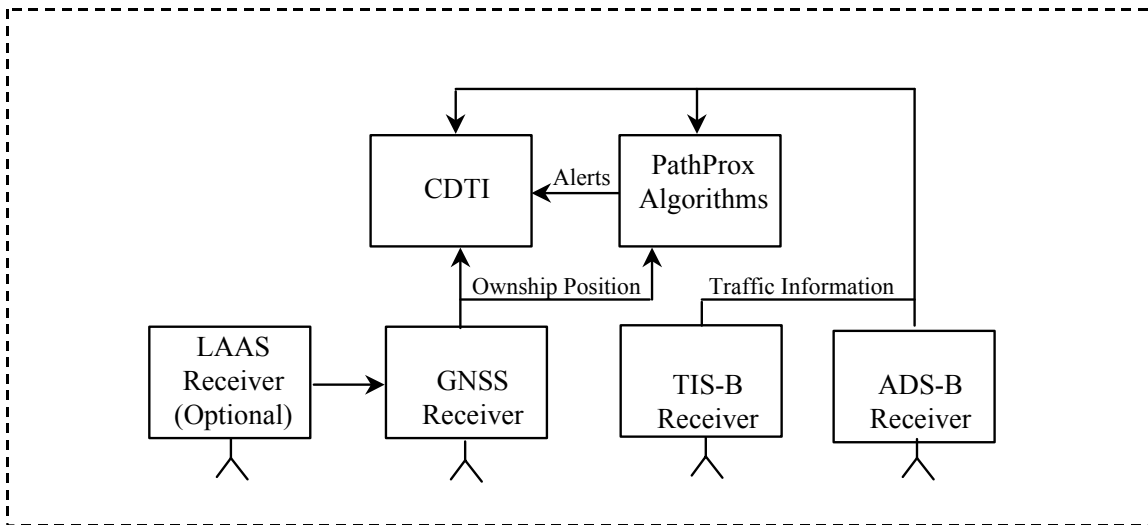


Figure 2. Avionics Infrastructure

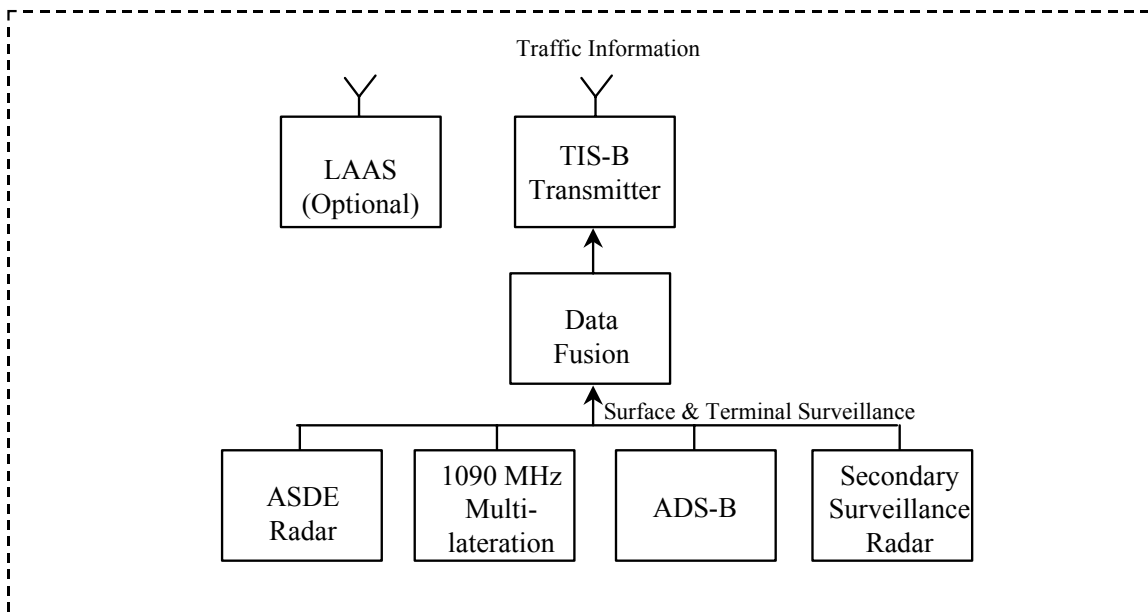


Figure 3. Ground Equipment Infrastructure

PathProx will also operate when TIS-B is not present at an airport, by using traffic information available from ADS-B equipped aircraft.

Alerting Concept

PathProx is designed to handle over forty different runway incursion scenarios.

Figure 4 depicts four of the most common scenarios [10]. The scenario in Figure 4A is when an aircraft taxis onto an active runway while an arrival aircraft is attempting to land. The scenario in Figure 4B is also when an aircraft taxis onto an active runway, this time when a departing aircraft is attempting to takeoff. The scenario in Figure 4C occurs when there is a loss of separation between a departing

aircraft and an arrival. The scenario in Figure 4D occurs when there is a conflict on a converging runway operation. This is one of the more challenging scenarios because of the use of Land and Hold Short Operations (LAHSO) at many airports. In these operations aircraft are allowed to land and hold short of the intersection of the converging runway, while allowing traffic to operate independently on the other runway.

PathProx will provide two types of alerts, analogous to TCAS. A Runway Traffic Alert (RTA) is generated when own aircraft is projected to be involved in a runway incursion with other traffic. The Runway Traffic Alert acts to caution the pilot of a potential incursion. A Runway Conflict Alert (RCA) is provided when an actual runway incursion has been detected, and there is potential for collision. An RCA indicates that the aircraft involved in the conflict need to take evasive action to avoid the potential collision. Unlike TCAS, PathProx will not provide guidance information to the pilot for taking evasive action. The reason for that is the

number and complexity of the scenarios will make it difficult to correctly identify the proper evasive action to take in every situation. Information that will be provided with each alert will include identification of the incurring aircraft (or vehicle), the runway associated with the aircraft, separation distance and time to conflict. It is assumed that the alerts will be displayed on a moving map display tailored to the airport surface (Figure 5). This should provide enough information to the pilot to determine proper evasive action.

Two of the benefits of PathProx is that it does not rely on air traffic controller input; nor does it rely on ground systems to generate incursion alert messages. This makes it possible for equipped aircraft to reap the benefit of increased safety even when flying into airports that are not equipped with ground-based incursion prevention and detection systems.

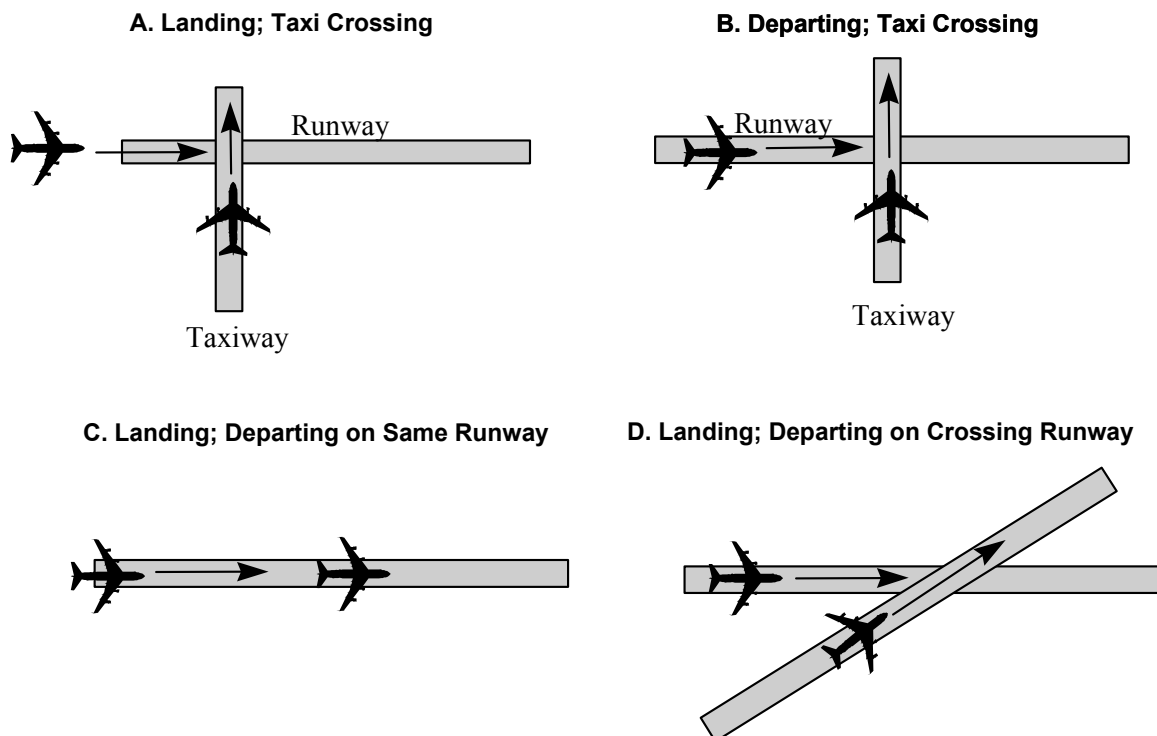


Figure 4. Common Runway Incursion Scenarios



Figure 5. Conflict Alert Display (NASA)

Testing

NASA Langley Research Center is currently conducting simulator and flight tests of PathProx as part of the Runway Incursion Prevention System (RIPS) program. Flight tests are scheduled to take place at Dallas Fort Worth Airport during September and October of this year. More extensive simulation and modeling tests are planned for 2001.

Summary

The airport surface and its vicinity remains the last phase of aircraft operations that does not provide conflict alerts, either to air traffic control or to the pilots. An airborne based alerting system – PathProx, is being developed to help fill that void. As implemented in Rannoch Corporation's PathProx, a cockpit based runway incursion alerting system has the potential to significantly reduce the risk of accidents due to runway incursions.

References

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